United States Government Accountability Office

GAO

Applied Research and Methods

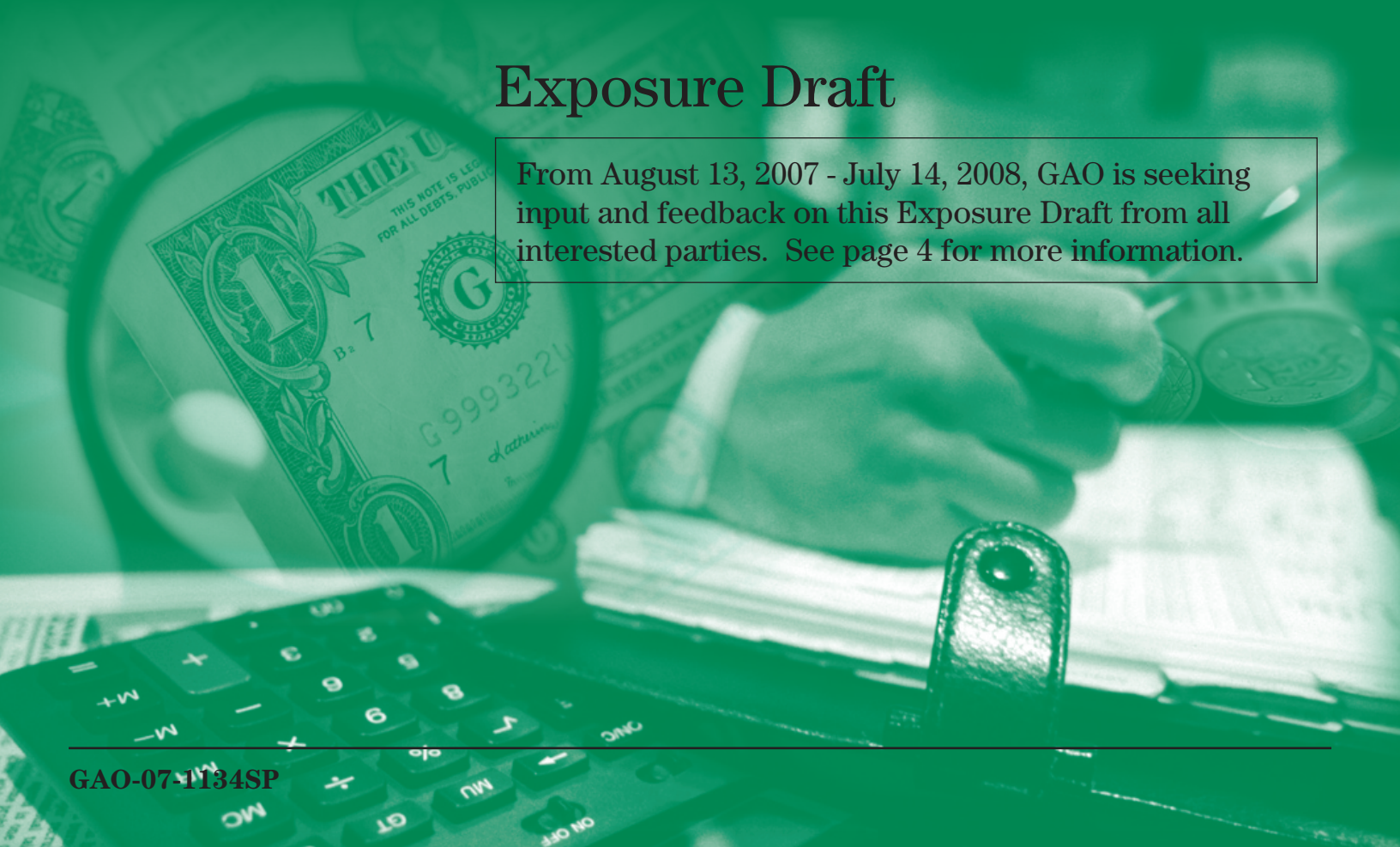
July 2007

COST ASSESSMENT GUIDE

Best Practices for Estimating and Managing Program Costs

Exposure Draft

From August 13, 2007 - July 14, 2008, GAO is seeking input and feedback on this Exposure Draft from all interested parties. See page 4 for more information.



GAO-07-1134SP

that are at the core of effective cost estimating. Specifically, embedded in several of the questions were requirements for using (1) formal cost models; (2) structured and documented processes for determining the software size and reuse inputs to the models; and (3) relevant, measured, and normalized historical cost data (estimated and actual) to calibrate the models.

GAO found that Customs did not satisfy any of these requirements. Instead of using a cost model, it used an unsophisticated spreadsheet to extrapolate the cost of each ACE increment. Its approach to determining software size and reuse was not documented and was not well supported or convincing. Customs had no historical project cost data when it developed the $1.05 billion estimate and did not account for relevant, measured, and normalized differences in the increments. Clearly, such fundamental changes can dramatically affect system costs and should have been addressed explicitly in Customs' cost estimates.

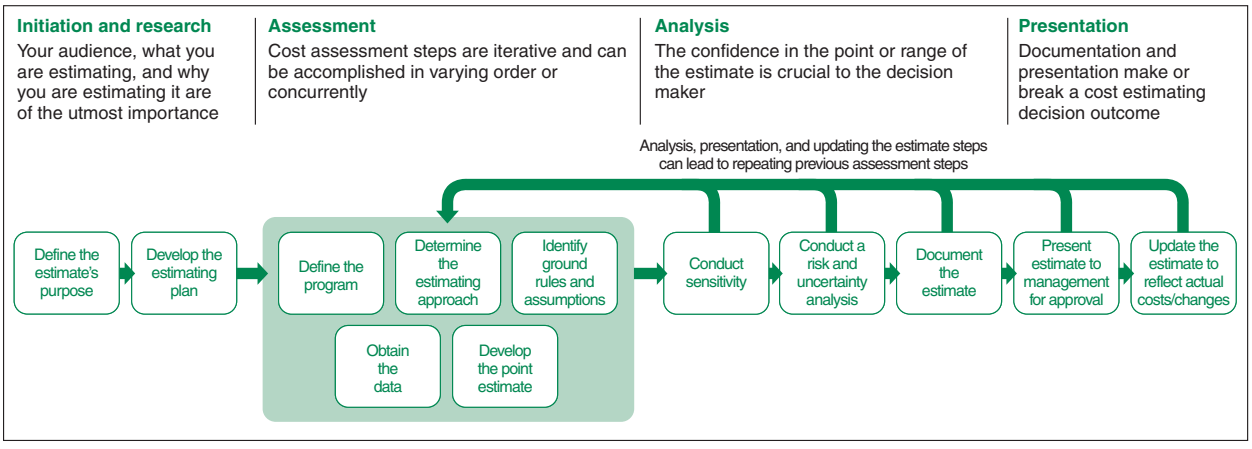
[a]GAO, *Customs Service Modernization: Serious Management and Technical Weaknesses Must Be Corrected,* GAO/AIMD-99-41 (Washington, D.C.: Feb. 26, 1999).

As a result of findings like those in case studies 1 and 2, the *Cost Guide* will provide best practice processes, standards, and procedures for developing, implementing, and evaluating cost estimates and EVM systems and data. By satisfying these criteria, agencies should be able to better manage their programs and inform decision makers of the risks involved.

A RELIABLE PROCESS FOR DEVELOPING CREDIBLE COST ESTIMATES

Certain best practices should be followed if accurate and credible cost estimates are to be developed. These best practices represent an overall process of established, repeatable methods that result in quality cost estimates that are comprehensive and accurate and that can be easily and clearly traced, replicated, and updated. The cost estimating process is shown in figure 1.

Figure 1: The Cost Estimating Process



Source: GAO.

We have identified 12 steps that if followed correctly, should result in reliable and valid cost estimates that management can use for making informed decisions. Table 2 identifies each of the 12 steps and links them to their corresponding chapters in this guide.

Table 2: The Twelve Steps of a High-Quality Cost Estimating Process

Step	Description	Associated task	Where discussed
1	Define estimate's purpose	Determine • the estimate's purpose; • the level of detail required; • who will receive the estimate; • the overall scope of the estimate.	Chapter 5
2	Develop estimating plan	• Determine the cost estimating team. • Outline the cost estimating approach. • Develop the estimate timeline. • Determine who will do the independent cost estimate. • Develop the team's master schedule.	Chapters 5 and 6
3	Define program characteristics	Identify in a technical baseline description document • the program's purpose; • its system and performance characteristics; • any technology implications; • all system configurations; • program acquisition schedule; • acquisition strategy; • relationship to other existing systems; • support (manpower, training, etc.) and security needs; • risk items; • system quantities for development, test, and production; • deployment and maintenance plans; • predecessor or similar legacy systems.	Chapter 7
4	Determine estimating approach	• Define work breakdown structure (WBS) and describe each element in a WBS dictionary; a major automated information system may have only a cost element structure.[a] • Choose the estimating method best suited for each WBS element. • Identify potential cross-checks for likely cost and schedule drivers. • Develop a cost estimating checklist.	Chapter 8
5	Identify ground rules and assumptions	Clearly define what is included and excluded from the estimate. Identify global and program specific assumptions such as • the estimate's base year, including time-phasing and life cycle; • program schedule information by phase; • program acquisition strategy; • any schedule or budget constraints; • inflation assumptions; • travel costs; • equipment the government is to furnish; • prime contractor and major subcontractors; • use of existing facilities or new modification or development; • technology refresh cycles; • technology assumptions and new technology to be developed; • commonality with legacy systems and assumed heritage savings; • effects of new ways of doing business.	Chapter 9
6	Obtain data	• Create a data collection plan with emphasis on collecting current and relevant technical, programmatic, cost, and risk data. • Investigate possible data sources.	Chapter 10

Step	Description	Associated task	Where discussed
		• Collect data and normalize them for cost accounting, inflation, learning, and quantity adjustments • Analyze the data to look for cost drivers, trends, and outliers; compare results against rules of thumb and standard factors derived from historical data. • Interview data sources and document all pertinent information, including an assessment of data reliability and accuracy. • Store data for future estimates.	
7	Develop point estimate	• Develop the cost model by estimating each WBS element, using the best methodology from the data collected. • Include all estimating assumptions in the cost model. • Express costs in constant year dollars. • Time-phase the results by spreading costs in the years they are expected to occur, based on the program schedule. • Sum the WBS elements to develop the overall point estimate. • Validate the estimate by looking for errors like double counting and omitting costs. • Compare estimate against the independent cost estimate and examine where and why there are differences. • Perform cross-checks on cost drivers to see if results are similar. • Update the model as more data become available or as changes occur; compare results against previous estimates.	Chapters 11, 12, and 15
8	Conduct sensitivity analysis	• Test the sensitivity of cost elements to changes in estimating input values and key assumptions. • Identify effects of changing the program schedule or quantities on the overall estimate. • On the basis of this analysis, determine which assumptions are key cost drivers and which cost elements are affected most by changes.	Chapter 13
9	Conduct risk and uncertainty analysis	• Determine the level of cost, schedule, and technical risk associated with each WBS element and discuss with technical experts. • Analyze each risk for its severity and probability of occurrence. • Develop minimum, most likely, and maximum ranges for each element of risk. • Use an acceptable statistical analysis methodology (e.g., Monte Carlo simulation) to develop a confidence interval around the point estimate. • Determine type of risk distributions and reason for their use. • Identify the confidence level of the point estimate. • Identify the amount of contingency funding and add this to the point estimate to determine the risk-adjusted cost estimate. • Recommend that the project or program office develop a risk management plan to track and mitigate risks.	Chapter 14
10	Document the estimate	• Document all steps used to develop the estimate so that it can be recreated quickly by a cost analyst unfamiliar with the program and produce the same result. • Document the purpose of the estimate, the team that prepared it, and who approved the estimate and on what date. • Describe the program, including the schedule and technical baseline used to create the estimate. • Present the time-phased life-cycle cost of the program. • Discuss all ground rules and assumptions.	Chapter 16

Step	Description	Associated task	Where discussed
		• Include auditable and traceable data sources for each cost element. • Document for all data sources how the data were normalized. • Describe in detail the estimating methodology and rationale used to derive each WBS element's cost (more detail rather than too little is preferred). • Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified. • Document how the estimate compares to the funding profile. • Track how this estimate compares to previous estimates, if applicable.	
11	Present estimate to management for approval	• Develop a briefing that presents the documented life-cycle cost estimate for management approval, including o an explanation of the technical and programmatic baseline and any uncertainties; o a comparison to an independent cost estimate (ICE) with explanations of any differences; o a comparison of the estimate (life-cycle cost estimate (LCCE) or independent cost estimate to the budget; and o enough detail so the presenter can easily defend the estimate by showing how it is accurate, complete, and high in quality. • Focus the briefing, in a logical manner, on the largest cost elements and drivers of cost. • Make the content crisp and complete so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results. • Make backup slides available for more probing questions. • Act on and document feedback from management. • The cost estimating team should request acceptance of the estimate.	Chapter 17
12	Update the estimate to reflect actual costs and changes	• Update the estimate to o reflect any changes in technical or program assumptions or o keep it current as the program passes through new phases or milestones. • Replace estimates with EVM EAC and Independent estimate at completion (EAC) from the integrated EVM system. • Report progress on meeting cost and schedule estimates. • Perform a post mortem and document lessons learned for elements whose actual costs or schedules differ from the estimate. • Document all changes to the program and how they affect the cost estimate.	Chapters 16 and 18

Source: GAO, DHS, DOD, DOE, NASA, SCEA, Industry.

[a]In a data-rich environment, the estimating approach should precede the investigation of data sources; in reality, a lack of data often determines the approach.

Each of the 12 steps is important for ensuring that high-quality cost estimates are developed and delivered in time to support important decisions. Unfortunately, we have found that some agencies do not incorporate all the steps and, as a result, their estimates are unreliable. For example, in 2003, we completed a cross-cutting review at the

National Aeronautics and Space Administration (NASA) that showed that the lack of an overall process affected NASA's ability to create credible cost estimates (case study 3).

Case Study 3: Following Cost Estimating Steps, from *NASA,* GAO-04-642

NASA's lack of a quality estimating process resulted in unreliable cost estimates throughout each program's life cycle.[a] As of April 2003, the baseline development cost estimates for 27 NASA programs varied considerably from their initial baseline estimates. More than half the programs' development cost estimates increased. For some of these programs, the increase was as much as 94 percent. In addition, the baseline development estimates for 10 programs that GAO reviewed in detail were rebaselined—some as many as four times.

The Checkout and Launch Control System (CLCS) program—whose baseline had increased from $206 million in fiscal year 1998 to $399 million by fiscal year 2003—was ultimately terminated. CLCS' cost increases resulted from poorly defined requirements and design and fundamental changes in the contractors' approach to the work. GAO also found that

- the description of the program objectives and overview in the program commitment agreement was not the description used to generate the cost estimate;
- the total life cycle and WBS were not defined in the program's life-cycle cost estimate;
- the 1997 nonadvocate review identified the analogy to be used as well as six different projects for parametric estimating, but no details on the cost model parameters were documented; and
- no evidence was given to explain how the schedule slip, from June 2001 to June 2005, affected the cost estimate.

GAO recommended that NASA establish a framework for developing life-cycle cost estimates that would require each program to base its cost estimates on a WBS that encompassed both in-house and contractor efforts and also to prepare a cost analysis requirements description. NASA concurred with the recommendation; it intended to revise its processes and its procedural requirements document and cost-estimating handbook accordingly.

[a]GAO, *NASA: Lack of Disciplined Cost-Estimating Processes Hinders Effective Program Management,* GAO-04-642 (Washington, D.C.: May 28, 2004).

NASA has since developed a cost estimating handbook that reflects a "renewed appreciation within the Agency for the importance of cost estimating as a critical part of project formulation and execution." It has also stated that "There are newly formed or regenerated cost organizations at NASA Headquarters . . . . The field centers cost organizations have been strengthened, reversing a discouraging trend of decline." Finally, NASA reported in its cost handbook that "Agency management, from the Administrator and Comptroller on down, is visibly supportive of the cost estimating function."[13]

While these are admirable improvements, even an estimate that meets all these steps may be of little use or may be overcome by events if it is not ready when needed. Timeliness is just as important as quality. In fact, the quality of a cost estimate may be hampered if the time to develop it is compressed. When this happens, there may not be enough time to collect historical data. Since data are the key driver of an estimate's quality, their lack increases the risk that the estimate may not be reliable. In addition,

[13]NASA, Cost Analysis Division, *2004 NASA Cost Estimating Handbook* (Washington, D.C.: 2004), p. i. http://www.nasa.gov/offices/pae/organization/cost_analysis_division.html.

when time is a factor, an independent cost estimate (ICE) may not be developed further, adding to the risk that the estimate may be overly optimistic. This is not an issue for DOD's major defense acquisition programs, because an ICE is required for certain milestones.

Relying on a standard process that emphasizes pinning down the technical scope of the work, communicating the basis on which the estimate is built, identifying the quality of the data, determining the level of risk, and thoroughly documenting the effort should result in cost estimates that are defensible, consistent, and trustworthy. Furthermore, this process emphasizes the idea that a cost estimate should be a "living document," meaning that it will be continually updated as actual costs begin to replace the original estimates. This last step links cost estimating with data that are collected by an EVM system, so that lessons learned can be examined for differences and their reasons. It also provides valuable information for strengthening the credibility of future cost estimates, allowing for continuous process improvement.